

1. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a continuous caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.1 to 2 inches;
- (d) hot rolling said slab into a sheet product;
- (e) solution heat treating said sheet product;
- (f) quenching said sheet product;
- (g) forming said sheet into a tube having a seam;
- (h) welding said seam to provide a seam welded tube having an outer diameter and having end regions;
- (i) placing said seam welded tube in a forming die;
- (j) hydroforming said seam welded tube to form said automotive aluminum drive shaft tube member; and

(k) aging said aluminum drive shaft tube member to increase strength properties.

2. In the production of an aluminum drive shaft in accordance with claim 1 wherein silicon is maintained in the range of 0.4 to 0.6 wt.%.

3. In the production of an aluminum drive shaft in accordance with claim 1 wherein magnesium is maintained in the range of 0.7 to 1.1 wt.%.

4. In the production of an aluminum drive shaft in accordance with claim 1 wherein iron is maintained in the range of 0.1 to 0.5 wt.%.

5. In the production of an aluminum drive shaft in accordance with claim 1 wherein said continuous caster is a belt caster.

6. In the production of an aluminum drive shaft in accordance with claim 1 including solution heat treating said sheet product in a temperature range of 800° to 1000°F.

7. In the production of an aluminum drive shaft in accordance with claim 1 including solution heat treating said sheet product in a temperature range of 850° to 1000°F.

8. In the production of an aluminum drive shaft in accordance with claim 7 including solution heat treating for about 0.5 minutes to 2 hours.

9. In the production of an aluminum drive shaft in accordance with claim 1 including continuously solution heat treating said sheet product after hot rolling.

10. In the production of an aluminum drive shaft in accordance with claim 9 including forced cooling said hot rolled sheet product after said solution heat treating.

11. In the production of an aluminum drive shaft in accordance with claim 1 including hot rolling said slab to a hot rolled sheet product followed by cold rolling.

12. In the production of an aluminum drive shaft in accordance with claim 11 wherein said cold rolling provides a 25 to 60% gauge reduction.

13. In the production of an aluminum drive shaft in accordance with claim 11 including solution heat treating and quenching said cold rolled sheet product.

14. In the production of an aluminum drive shaft in accordance with claim 13 wherein said cold rolled sheet product is solution heat treating in a temperature range of 800° to 1000°F.

15. In the production of an aluminum drive shaft in accordance with claim 1 wherein after hydroforming said aluminum drive shaft tube member has a wall thickness thinner between end regions and thicker at an end region.

16. In the production of an aluminum drive shaft in accordance with claim 1 wherein said hydroforming increases the outer diameter of the welded tube between the end regions and decreases wall thickness to produce a relatively long tube section of increased diameter and thinner wall thickness than at the end regions.

17. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a continuous caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.1 to 2 inches;
- (d) hot rolling said slab into a sheet product;
- (e) solution heat treating said sheet product;
- (f) quenching said sheet product;
- (g) forming said sheet into a tube having a seam;
- (h) welding said seam to provide a seam welded tube having an outer diameter and having end regions;
- (i) decreasing end regions of the outer diameter of the welded tube to provide a relatively short section of reduced diameter at both ends having an increase in wall thickness; and

(j) aging said aluminum drive shaft tube member to increase strength properties.

18. In the production of an aluminum drive shaft in accordance with claim 17 including decreasing said outer diameter using swaging or reducing die.

19. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

(a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;

(b) providing a belt caster for continuously casting said molten aluminum alloy;

(c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.4 inch to 1.75 inch;

(d) hot rolling said slab into a hot rolled sheet product, said hot rolling starting in a temperature range of 750° to 1000°F and ending in a temperature of 425° to 950°F;

(e) solution heat treating, quenching and aging said hot rolled sheet product to a T4 condition, said hot rolled sheet product having a tensile strength in the range of 20 to 35 KSI, a minimum yield strength of 9 KSI, and an elongation of greater than 15%;

(f) forming said sheet into a tube having a seam;

(g) welding said seam to provide a seam welded tube;

(h) placing said seam welded tube in a forming die;

(i) hydroforming said seam welded tube to form said automotive aluminum drive shaft tube member; and

(j) aging said aluminum drive shaft tube member to increase strength properties.

20. The method in accordance with claim 19 wherein magnesium is maintained in the range of 0.7 to 1.1 wt.%.

21. The method in accordance with claim 19 wherein iron is maintained in the range of 0.1 to 0.5 wt.%.

22. The method in accordance with claim 19 including solution heat treating said hot rolled sheet in a temperature range of 800° to 1000°F.

23. The method in accordance with claim 19 including solution heat treating said hot rolled sheet in a temperature range of 850° to 1000°F.

24. The method in accordance with claim 22 including solution heat treating for about 0.5 minutes to 3 hours.

25. The method in accordance with claim 19 including continuously solution heat treating said sheet product.

26. The method in accordance with claim 19 including cold rolling said hot rolled sheet product.

27. The method in accordance with claim 26 wherein said cold rolling provides a 25 to 60% gauge reduction.

28. The method in accordance with claim 26 including solution heat treating and quenching said cold rolled sheet product.

29. In the production of an aluminum drive shaft in accordance with claim 19 wherein after hydroforming said aluminum drive shaft tube member has a wall thickness thinner between end regions and thicker at an end region.

30. In the production of an aluminum drive shaft in accordance with claim 19 wherein said hydroforming increases the outer diameter of the welded tube between the end regions and decreases wall thickness to produce a relatively long tube section of increased diameter and thinner wall thickness than the end regions.

31. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a belt caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.4 inch to 1.75 inch;
- (d) hot rolling said slab into a hot rolled sheet product, said hot rolling starting in a temperature range of 750° to 1000°F and ending in a temperature of 425° to 950°F;
- (e) solution heat treating, quenching and aging said hot rolled sheet product to a T4 condition, said hot rolled sheet product having a tensile strength in the range of 20 to 35 KSI, a minimum yield strength of 9 KSI, and an elongation greater than 15%;
- (f) forming said sheet into a tube having a seam;
- (g) welding said seam to provide a seam welded tube;

- (h) decreasing end regions of the outer diameter of the welded tube to provide a relatively short section of reduced diameter at both ends having an increase in wall thickness; and
- (i) aging said aluminum drive shaft tube member to increase strength properties.

32. In the production of an aluminum drive shaft in accordance with claim 31 including decreasing said outer diameter using swaging or reducing die.

33. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a belt caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness of 0.4 to 1.75 inches;
- (d) hot rolling said slab into a hot rolled sheet product;
- (e) cold rolling said hot rolled sheet product to a thickness in the range of 0.06 inch to 0.2 inch to provide a cold rolled sheet product;
- (f) solution heat treating, quenching and aging said cold rolled sheet product to provide a solution heat treated sheet product, said solution heat treated sheet product having a tensile yield strength in the range of 20 to 35 KSI, a minimum yield strength of 9 KSI, and an elongation of greater than 15%;

- (g) forming said solution heat treated, quenched and aged sheet product into a tube having a seam;
- (h) welding said seam to provide a seam welded tube having an outer diameter and having end regions;
- (i) placing said seam welded tube in a forming die;
- (j) hydroforming said seam welded tube to form said automotive aluminum drive shaft tube member; and
- (k) aging said aluminum drive shaft tube member to increase strength properties.

34. In the production of an aluminum drive shaft in accordance with claim 33 wherein after hydroforming said aluminum drive shaft tube member has a wall thickness thinner between end regions and thicker at an end region.

35. In the production of an aluminum drive shaft in accordance with claim 33 wherein said hydroforming increases the outer diameter of the welded tube between the end regions and decreases wall thickness to produce a relatively long tube section of increased diameter and thinner wall thickness than at the end regions.

36. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a belt caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness of 0.4 to 1.75 inches;
- (d) hot rolling said slab into a hot rolled sheet product;
- (e) cold rolling said hot rolled sheet product to a thickness in the range of 0.06 inch to 0.2 inch to provide a cold rolled sheet product;
- (f) solution heat treating, quenching and aging said cold rolled sheet product to provide a solution heat treated sheet product, said solution heat treated sheet product having a tensile strength in the range of 20 to 35 KSI, a minimum yield strength of 9 KSI, and an elongation of greater than 15%;
- (g) forming said solution heat treated, quenched and aged sheet product into a tube having a seam;

(h) welding said seam to provide a seam welded tube having an outer diameter and having end regions;

(i) decreasing end regions of the outer diameter of the welded tube to provide a relatively short section of reduced diameter at both ends having an increase in wall thickness; and

(j) aging said aluminum drive shaft tube member to increase strength properties.

37. In the production of an aluminum drive shaft in accordance with claim 36 including decreasing said outer diameter using swaging or reducing die.

38. The method in accordance with claim 33 including solution heat treating, quenching and aging said cold rolled product to a T4-temper.

39. The method in accordance with claim 33 including homogenizing said slab prior to hot rolling.

40. The method in accordance with claim 39 including homogenizing in a temperature range of 900° to 1100°F.

41. The method in accordance with claim 39 including homogenizing in a temperature range of 950° to 1075°F.

42. The method in accordance with claim 40 including homogenizing for about 2 to 12 hours.

43. The method in accordance with claim 33 including continuously solution heat treating said cold rolled sheet product.

44. The method in accordance with claim 33 wherein said cold rolling provides a 25 to 60% gauge reduction.

45. A method for producing aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a belt caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness of 0.4 to 1.75 inches;
- (d) hot rolling said slab into a hot rolled sheet product, said hot rolling starting in a temperature range of 750°F to 1000°F and ending in a temperature range of 425° to 950°F;
- (e) homogenizing said hot rolled sheet product to provide an solution heat treated sheet product;
- (f) cold rolling said homogenized sheet product to a thickness in the range of 0.06 inch to 0.2 inch to provide a cold rolled sheet product;
- (g) solution heat treating and quenching said cold rolled sheet product to provide a solution heat treated and quenched sheet product;

- (h) forming said solution heat treated and quenched sheet product into a tube having a seam;
- (i) welding said seam to provide a seam welded tube having an outside diameter and having end regions;
- (j) placing said seam welded tube in a forming die;
- (k) hydroforming said seam welded tube to form said automotive aluminum drive shaft tube member; and
- (l) aging said aluminum drive shaft tube member to increase strength properties.

46. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, the remainder aluminum, incidental elements and impurities;
- (b) providing a belt caster for continuously casting said molten aluminum alloy;
- (c) casting said molten aluminum alloy into a slab having a thickness in the range of 0.1 to 2 inches;
- (d) hot rolling said slab into a hot rolled sheet product, said hot rolling starting in a temperature range of 750°F to 1000°F and ending in a temperature range of 425° to 950°F;
- (e) subjecting said hot rolled sheet product to a first solution heat treatment to provide a first solution heat treated sheet product;
- (f) cold rolling said first solution heat treated sheet product to a thickness in the range of 0.06 inch to 0.2 inch to provide a cold rolled sheet product;

(g) subjecting said cold rolled sheet product to a second solution heat treatment and then quenching and aging to a T4 condition to provide an aged sheet product having a tensile strength in the range of 20 to 35 KSI, a minimum yield strength of 9 KSI, and an elongation of greater than 15%;

(h) forming said aged sheet product into a tube having a seam;

(i) welding said seam to provide a seam welded tube having outside diameter and having end regions;

(j) placing said seam welded tube in a forming die;

(k) forming said seam welded tube to form said automotive aluminum drive shaft tube having end regions of relative short length having decreased outside diameter; and

(l) aging said aluminum drive shaft tube member to increase strength properties.

47. The method in accordance with claim 46 wherein said forming is achieved using hydroforming, swaging or a reducing die.

48. The method in accordance with claim 46 wherein said first solution heat treatment includes batch solution heat treating said hot rolled sheet product.

49. The method in accordance with claim 46 wherein said first solution heat treatment includes continuous solution heat treating said hot rolled sheet product.

50. The method in accordance with claim 46 including solution heat treating in a temperature range of 800° to 1000°F.

51. The method in accordance with claim 46 including solution heat treating in a temperature range of 850° to 1000°F.

52. The method in accordance with claim 46 wherein said cold rolling provides a 25 to 60% gauge reduction.

53. The method in accordance with claim 45 wherein homogenizing is carried out in a temperature range of 900° to 1100°F.

54. The method in accordance with claim 45 wherein said cold rolled sheet product has a thickness in the range of 0.06 inch to 0.2 inch.

55. In the production of an aluminum automotive drive shaft from a heat treatable aluminum alloy using a continuous caster to cast the alloy into a slab wherein in said production an aluminum drive shaft tube member is joined to end members to form the drive shaft, the aluminum drive shaft tube member made by the method comprising:

- (a) providing a molten aluminum alloy consisting essentially of 0.2 to 0.8 wt.% Si, 0.05 to 0.4 wt.% Cu, 0.45 to 1.2 wt.% Mg, 0.04 to 0.35 wt.% Cr, 0.7 wt.% max. Fe, 0.15 wt.% max. Mn, 0.25 wt.% max. Zn, 0.15 wt.% max. Ti, the remainder aluminum, incidental elements and impurities;
- (b) providing a belt caster for continuously casting said molten aluminum alloy into a slab having a thickness in the range of 0.4 inch to 1.75 inch;
- (c) hot rolling said slab into a hot rolled sheet product starting in a temperature range of 750° to 1000°F and ending in a temperature range of 425° to 950°F;
- (d) continuously annealing said hot rolled sheet product in a temperature range of 750° to 1000°F to provide a fully recrystallized product;
- (e) cold rolling said fully recrystallized product to a cold rolled sheet product having a thickness in the range of 0.06 inch to 0.2 inch;

(f) thereafter, continuously solution heat treating said cold rolled sheet product then quenching and aging to a T4 condition to provide a sheet product in the T4 condition;

(g) forming said sheet in the T4 condition into a tube having seam;

(h) welding said seam to provide a seam welded tube;

(i) placing said seam welded tube in a forming die having an outside diameter and end regions;

(j) hydroforming said seam welded tube to form said automotive aluminum drive shaft tube having a portion thereof between said end regions having increased diameter and thinned wall thickness; and

(k) aging said aluminum drive shaft tube member to increase strength properties.

56. The drive shaft produced by the method of claim 1.

57. The drive shaft produced by the method of claim 19.

58. The drive shaft produced by the method of claim 33.

59. The drive shaft produced by the method of claim 45.

60. The drive shaft produced by the method of claim 46.

61. The drive shaft produced by the method of claim 57.